AD A147 423 SNOW CHARACTERIZATION MEASUREMENTS FROM SNOW-TWO/SMOKE WEEK VI(U) AIR FORCE GEOPHYSICS LAB HANSCOM AFB MA B A MAIN ET AL. 26 OCT 84 AFGL-TR-84-0277 1/1

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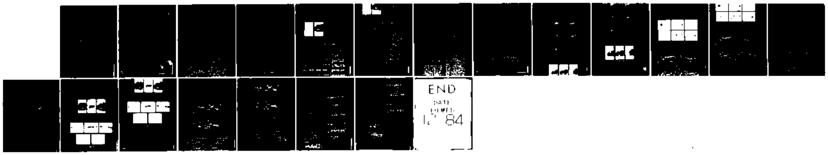

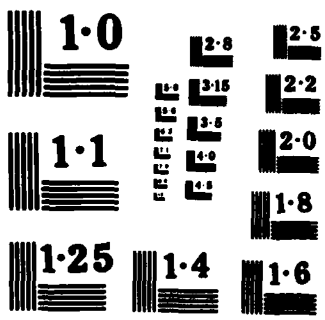
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ABSTRACT

Snow characterization measurements acquired during SNOW-TWO/Smoke Week VI are presented. A summary of data for eight days in January 1984 is given. These data consist of fall velocity, snow structure, and snow rate as recorded by laboratory prototype equipment. A new concept of back lighting on the fall velocity indicator is discussed and data examples shown. Snow rate plots, fall velocity and crystal type information are presented for selected periods.

1. Introduction

Air Force Geophysics Laboratory (AFGL) measurements recording the characteristics of naturally falling snow were made at Camp Grayling, MI during January 1984, in support of SNOW-TWO/Smoke Week VI. Other related experiments were held previously in the wint 1981-1982 at Camp Ethan Allen, Jericho, VT in support of SNOW-ONE-A, and at Camp Grayling, MI during December 1982, in support of SNOW-ONE-B. The sponsoring organization for these three experiments was the U.S. Army Cold Regions Research and Engineering Laboratory (FVI) to measure fall velocity, the snow structure recorder (SSR) for crystal identification, and the snow rate meter (SRM) to measure snowfall rate. These instruments are described and operational methods employed are discussed in previous reports, SNOW-ONE-A, Data Report (Berthel, 1982); SNOW-ONE-B, Data Report (Berthel, et.al., 1983); at Snow Symposium II (Berthel, et.al., 1982); SPIE Symposium (Plank, et. al., 1983); in an AFGL Report (Gibbons, et. al., 1983); and at Snow Symposium III (Berthel, et. al., 1983). This paper is concerned primarily with the presentation of data recorded by the three AFGL prototype instruments and analysed for future comparisons with results of other test participants. Instrument modifications are presented.

2. Instruments

The fall velocity indicator (FVI) and the snow structure recorder (SSR) were modified for use at SNOW-TWO/Smoke Week VI.

One problem with the FVI has persisted since instrument conception, that of weak or faded video images. In the front lighting configuration used for SNOW-ONE-A and SNOW-ONE-B, strobed light was reflected from the particle into the camera. The amount of reflected light varied with crystal size, shape, structure, and spatial configuration. This variation combined with limited video resolution and image magnification made it difficult for the analyst to identify salient features on which to base measurements. This problem was compounded when a particle tumbled or oscillated as it fell, and resulted in a broad scattering of fall velocity determinations.

To enhance particle definition, it was decided to modify the FVI to a back lighting concept. A strobe lamp was mounted at the rear of the sample chamber behind a ground-glass screen such that the diffused light would enter the camera directly. This configuration provides a shadow image of the falling particle with better contrast and definition. Further, this method has permitted

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AFGL interests lay in three directions: fall velocity measurements, crystal identification, and snow rate measurements. The needed information was gathered by three AFGL prototype instruments: the fall velocity indicator (SRM) to measure snowfall rate. These instruments are described and operational methods employed are discussed in previous reports, SNOW-ONE-A, Data Report (Berthel, 1982); SNOW-ONE-B, Data Report (Berthel, et.al., 1983); at Snow Symposium II (Berthel, et.al., 1982); SPIE Symposium (Plank, et. al., 1983); in an AFGL Report (Gibbons, et. al., 1983); and at Snow Symposium III (Berthel, et. al., 1983). This paper is concerned primarily with the presentation of data recorded by the three AFGL prototype instruments and analysed for future comparisons with results of other test participants. Instrument modifications are presented.

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To enhance particle definition, it was decided to modify the FVI to a back lighting concept. A strobe lamp was mounted at the rear of the sample chamber behind a ground-glass screen such that the diffused light would enter the camera directly. This configuration provides a shadow image of the falling particle with better contrast and definition. Further, this method has permitted a large reduction in the instrument's physical size. The only drawback to this method is that a mirror used to determine the third dimension of particles is now useless. As the FVI was not designed with particle identification as a prime function, this limitation is acceptable. Image comparison photos

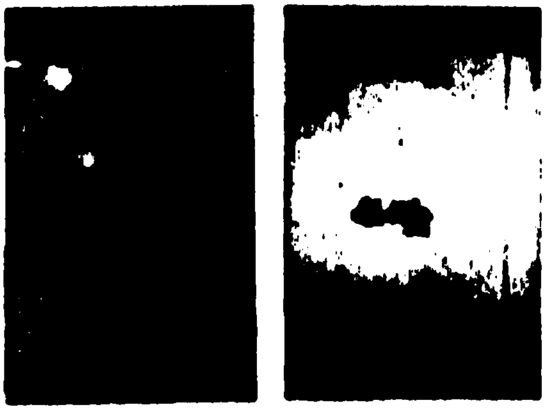
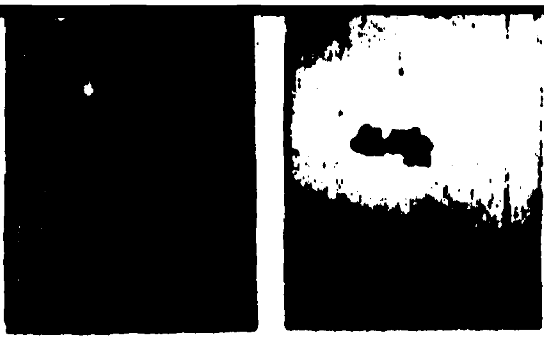


Figure 1. Image comparison showing a reflected image on the left and a shadow image on the right.

from SNOW-ONE-B and SNOW TWO/Smoke Week VI are seen in Figure 1. The sharper image is evident. The FVI has been modified since January 84 to increase the volume of snow entering the instrument and further improvements in both definition and collection capabilities are being planned. Consideration is being given to digitizing the video for future operations.

The snow structure recorder (SSR) had some minor changes made prior to the January tests. To increase the number of particles available for analysis, the 'stop/go' mechanism was stepped down from 1 1/2" to 3/4" to decrease belt movement, thus doubling the amount of time of each sample.

1984	FVI	SSR	SRM	REMARKS
9 Jan (84-01)	1022-1535	NONE	0815-0338(10th)	Occasional very light snow - mostly dendrites
12 Jan (84-03)	0724-0757	NONE	0705-0100(13th)	One period of light snow 1-2 mm stellars, some needles
13 Jan (84-04)	0845-1200	0845-1200	0855-0100(14th)	Sporadic light snow - stellars, aggregates of stellars and dendrites to 3mm.
16 Jan (84-05)	0730-23400	0730-2400	0747-0830(17th)	Periods of light to moderate snow-needles < 1mm, dendrites stellars, and aggregates to 3mm
17 Jan (84-06)	0801-1105	0801-1105	0847-0812(18th)	Two periods of very light snow dendrites <.3mm, aggregates of dendrites < 1mm.
22 Jan (84-11) (84-12)	[illegible] 1529-1730	[illegible] 1500-1730	[illegible] 1501-1731	Periods of light snow and flurries mostly stellars 2-3mm
23 Jan (84-13)	1405-0045	1405-0045	1422-0400(24th)	Periods of light and moderate snow- stellars, dendrites,



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13 Jan (84-04)	0845-1200	0845-1200	0855-0100(14th)	Sporadic light snow - stellars, aggregates of stellars and dendrites to 3mm.
16 Jan (84-05)	0758-23400	0758-2400	0747-0850(17th)	Periods of light to moderate snow-needles < 1mm, dendrites stellars, and aggregates to 5mm
17 Jan (84-06)	0901-1105	0901-1105	0847-0812(18th)	Two periods of very light snow dendrites <.5mm, aggregates of dendrites < 1mm.
22 Jan (84-11) (84-12)	0058-0528 1529-1730	0058-0528 1529-1730	0053-0530 1551-1751	Periods of light snow and flurries mostly stellars 2-3mm
23 Jan (84-13)	1405-2045	1405-2045	1422-0400(24th)	Periods of light and moderate snow- stellars, dendrites, amorphous, snow pellets 2-3mm
24 Jan (84-14)	1004-1208	1004-1208	0934-2354	Sporadic very light snow - snow pellets < 2mm

TABLE 1: DATA SUMMARY

Since the sampling area is essentially a slot, collection efficiency is dependent upon instrument position with respect to wind direction. The instrument has been mounted on a manually rotated table that allows it to be faced into the wind. Current plans are to mechanize this table and considerations are being made to similarly configure the FVI. The differences in the numbers of particles seen on the SSR during the recent experiments are significantly greater when compared to the numbers seen of the FVI.

The snow rate meter was essentially the same as that used in SNOW-ONE-B. As no fault with the SRM has been defined at this time, we presume the current readings to be correct. There are still concerns regarding air flow around the instruments, particularly the SRM, and smoke tracking studies are being conducted.

3. SNOW TWO/Smoke Week VI Data

The availability of personnel and budget restrictions prevented our participation in the first half of the SNOW-TWO/Smoke Week IV field exercise. Our Winnebago arrived on site after the Christmas recess and the instruments were in operation from January 8th thru January 24th. Snowfall measurements were made on eight (8) separate days. Table 1 shows these periods of operation and indicates snow intensities and observed crystal types. Of these days only two, 16 and 23 January, had sufficient snow falling into all three instruments to warrant further analyses. For the other six days, very light snowfall was recorded by the SRM with very little data obtained by the FVI and SSR.

The periods of study for the 16th and 23rd were determined by the number of particles seen on the fall velocity indicator (FVI). Because of the time consuming labor involved, the studies were limited to the first fifty free falling particles of each half hour period of comparatively heavy snowfall. In addition, crystal type and fall characterization were determined with as much accuracy as the limitations of the

snow rate data for these times were obtained.

4. 16 January 1984

On the 16th of January 1984, five study periods were selected: 2000, 2030, 2100, 2200, and 2230. All AFGL instruments were operating during these periods of relatively good snowfall. During these periods the first fifty free falling particles seen on the FVI were measured for largest dimension and for fall velocity. These measurements are shown in Figure 2, fall velocity vs size plots, with ℓ the largest physical dimension. The solid lines in the figures are the least square regression lines and the dashed lines show plus or minus one standard deviation. The dots are individual particles. The size range on this day is broad with largest dimensions from .3 mm to 16.6 mm and fall velocities from .3 m sec^{-1} to .95 m sec^{-1}. Snow types seen on the fall velocity indicator are many: stellars, spatial dendrites, aggregates of dendrites and graupellike snow in the first and fourth cases; dendrites added in the 2030 sample; rimed dendrites and snow pellets during the 2100 sample; and rimed plates during the 2230 samples. Particles less than .3 mm are not visible on the FVI because of the limited video resolution. There appears to be some relationship between particle size and fall velocity. Similarities do exist between current analyses and those preformed on SNOW-ONE-A and SNOW-ONE-B data as reported in SNOW-ONE-A and B Characterization Measurements and Data Analysis (Berthel, et al, 1983). The snow structure recorder(SSR) data was examined for the same five periods and particle types determine. Much the same particle variety observed on the FVI is seen on the SSR. Samples of the study periods are seen in Figure 3. The ability to move the instrument to face into the wind has made a significant change in the amount of data collected. The [illegible] configuration continues to give good results. Samples for the five time periods are shown in Figure 4. The snow rate meter (SRM)

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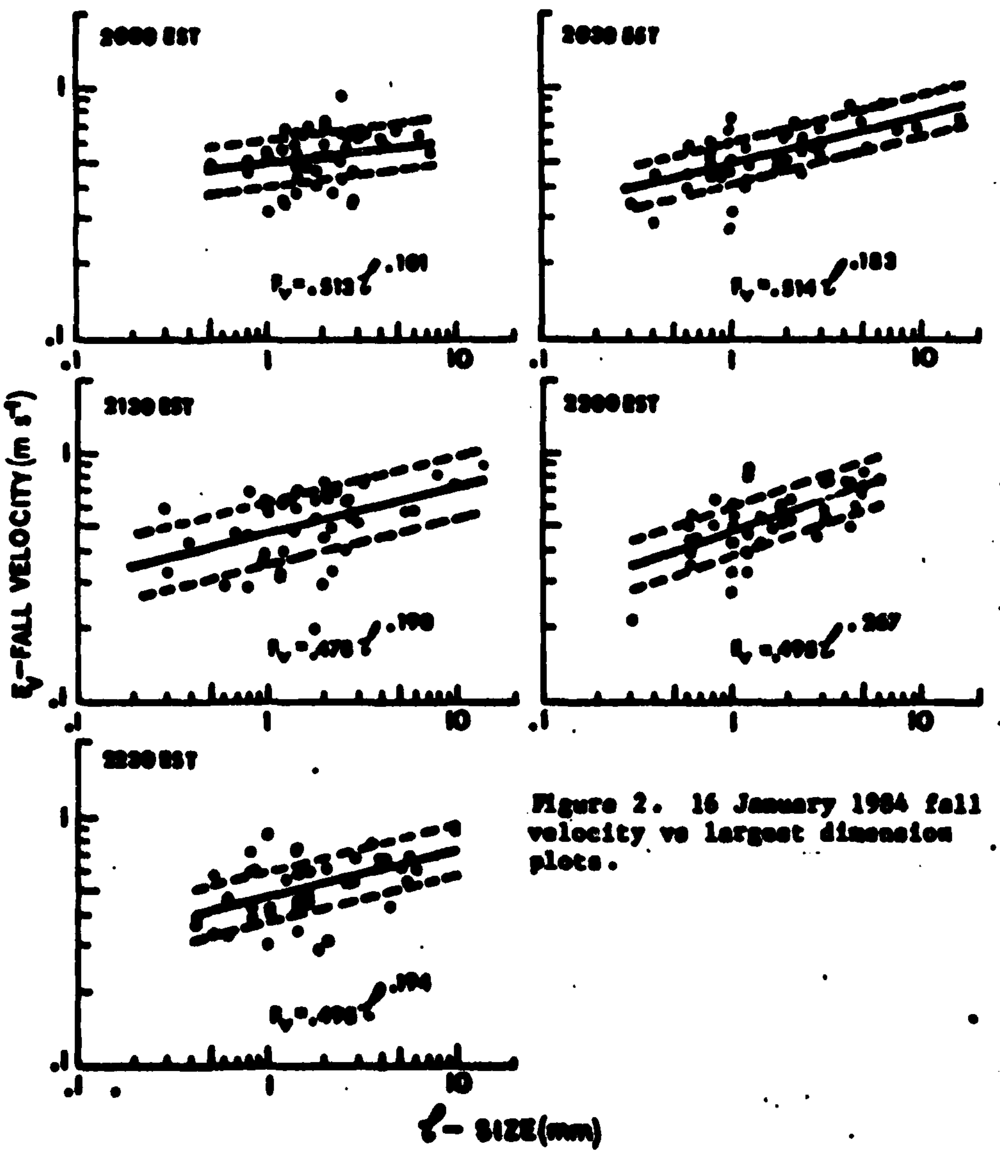
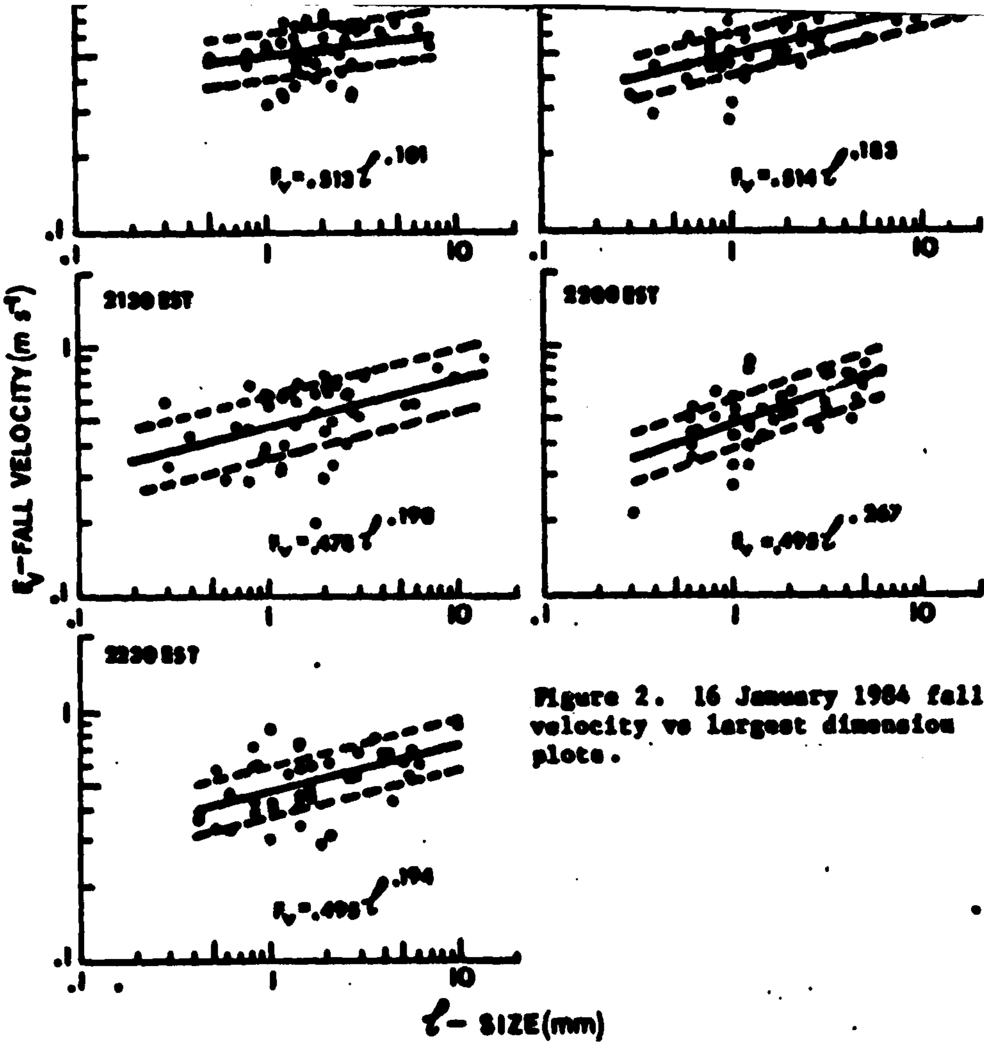


Figure 2. 16 January 1984 fall velocity vs largest dimension plots.



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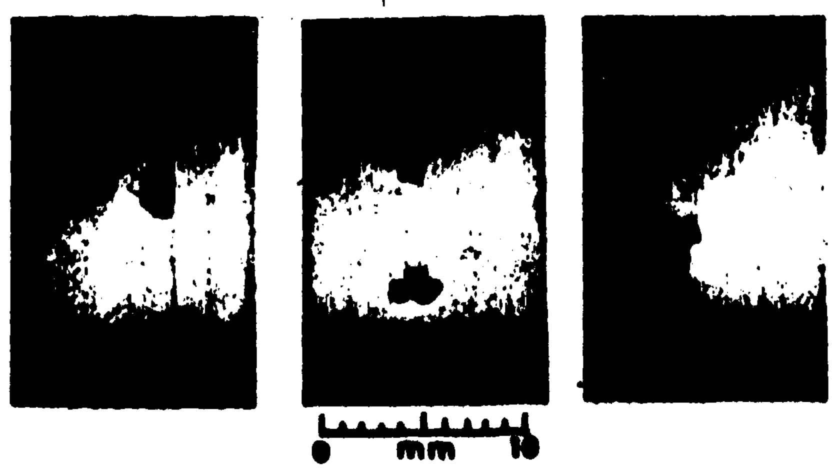

Figure 3. Fall velocity indicator particle images on 16 January 1984.

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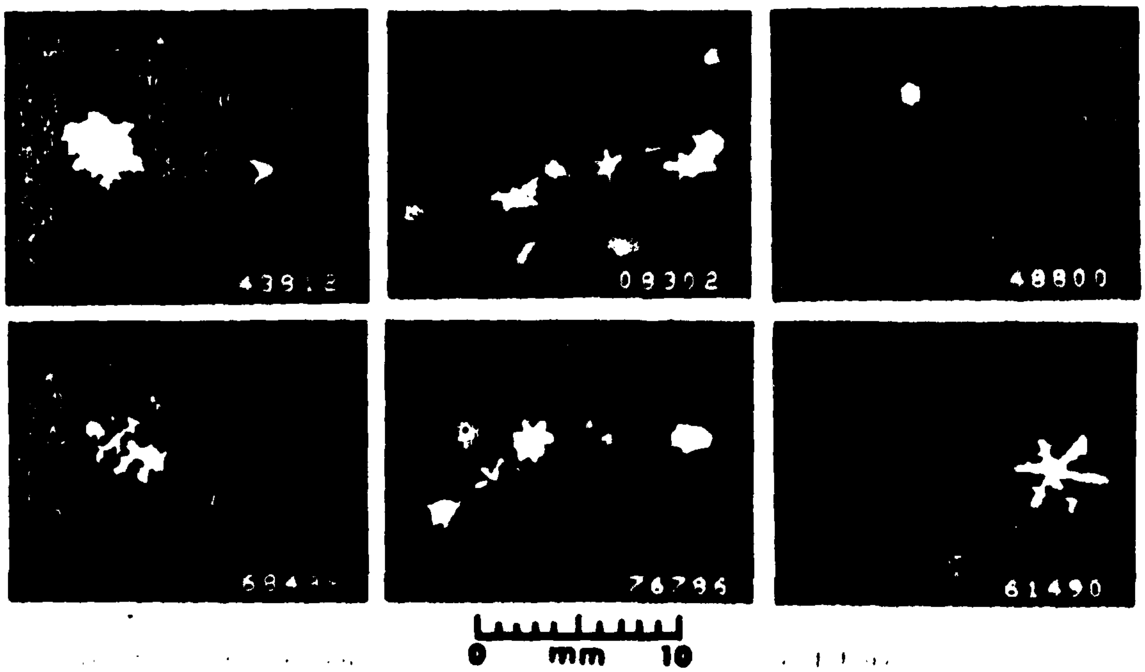
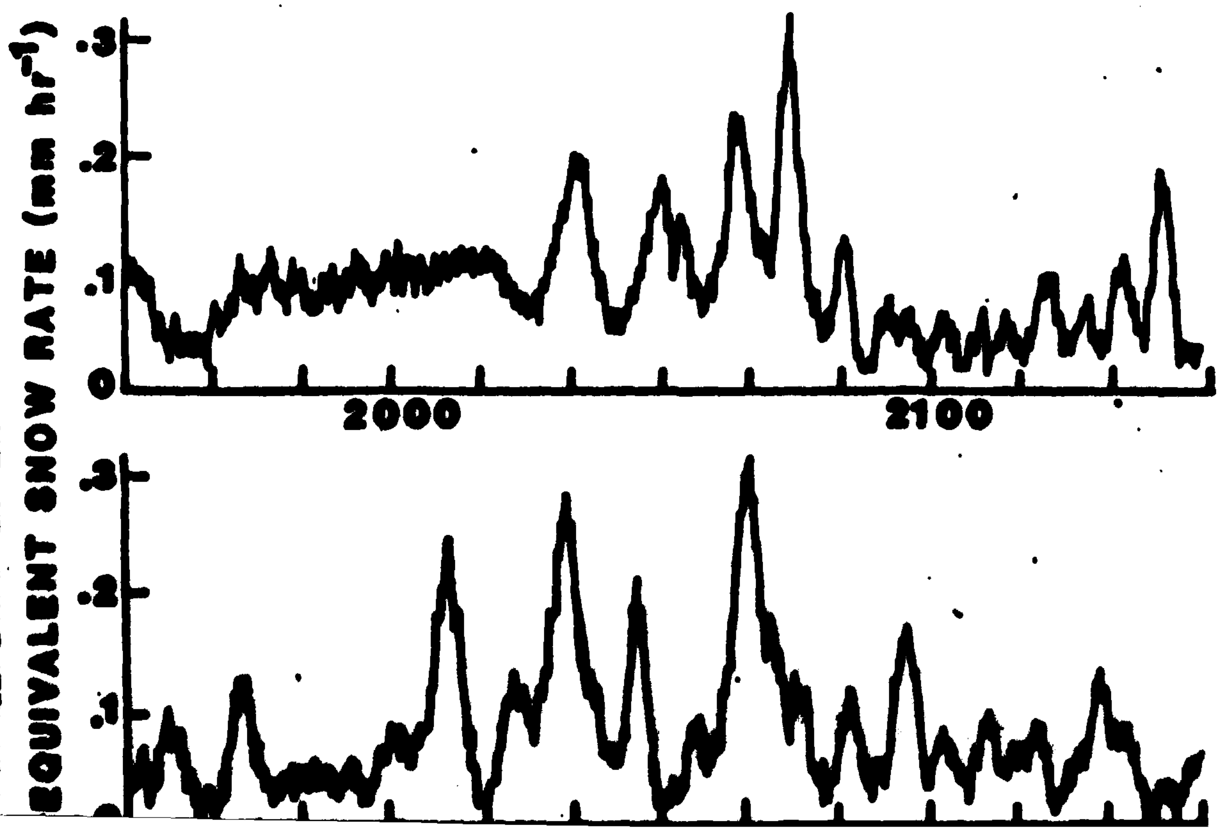
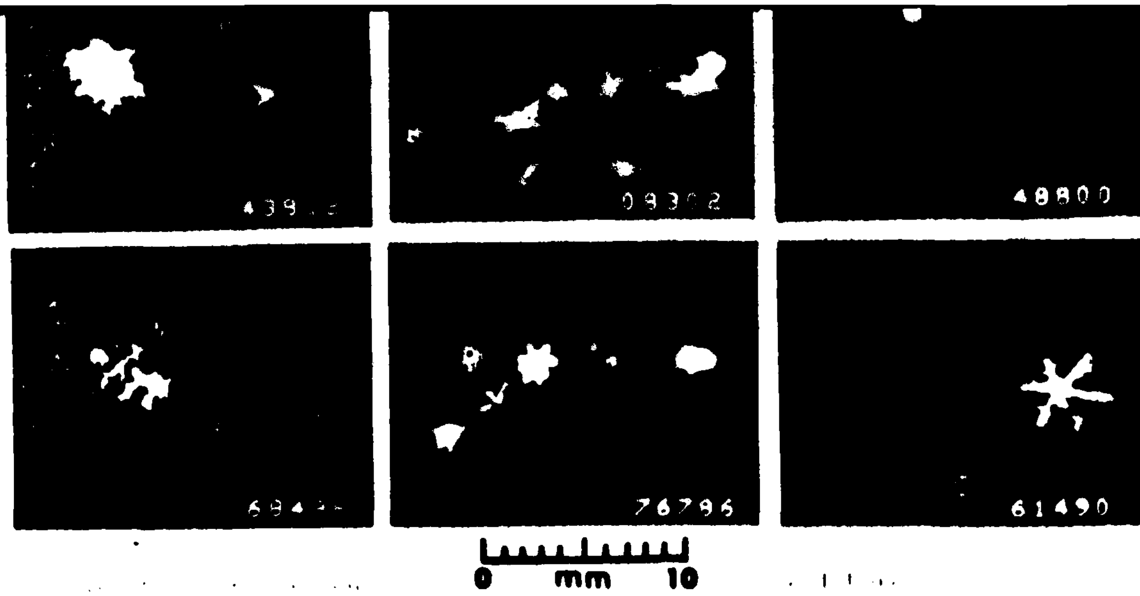


Figure 4. 16 January 1984 snow structure recorder samples.





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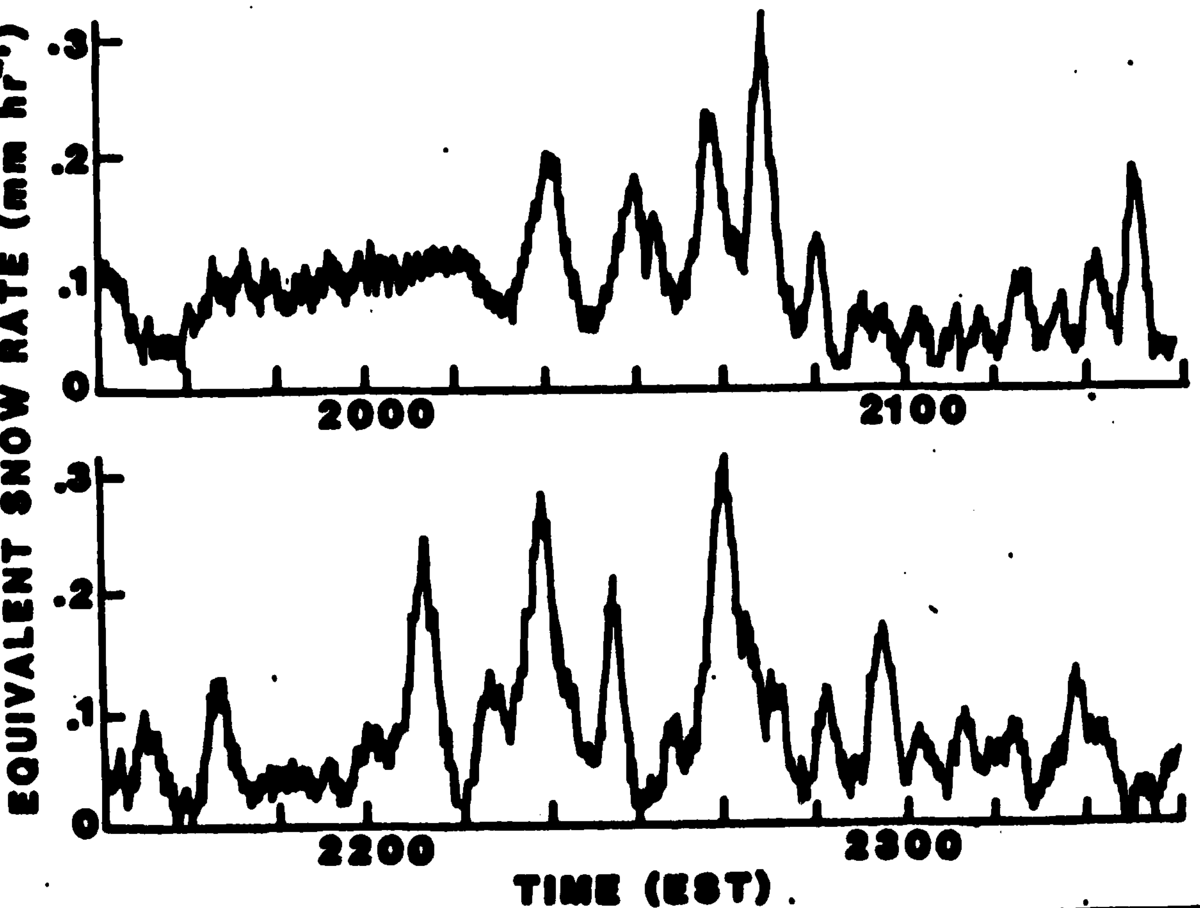

Figure 5. 16 January snow rate plots.

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recorded for much of the day with the heaviest period recording ~ .3 mm hr^{-1} from 2000 - 2300. Figure 5 shows the snow rate plots.

5. 23 January 1984

The 23rd of January data was analysed in the same fashion as the 16th. While the snow was more intense than on the 16th, it was so only for short periods. Three periods of relatively good snow were selected: 1430, 1500 and 1630. The first fifty free falling particles were measured for fall velocity and maximum dimension. These measurements are shown in Figure 6 fall velocity vs size plots with ℓ the largest physical dimension. The solid line is the least squares regression line and the dashed lines show plus or minus one standard deviation. The dots are individual particles. On this day the largest physical dimensions vary from .3 to 8.6 mm, considerably smaller than the 16.6 mm particles seen in the 16th Jan data. The fall velocities varied from .27 m sec^{-1} to 1.16 m sec^{-1}, a broader range than seen on the 16th. Crystal types seen on the FVI were varied. The first study period included aggregates of stellars, capped columns, rimed plates, spatial dendrites, graupellike snow; the second, rimed dendrites, stellars, aggregates of plates, columns, and graupellike snow; the third, aggregates of dendrites, rimed dendrites, graupellike snow, plates, and columns. Samples from these periods are shown in Figure 7. The snow structure recorder shows a similar variety with bullet rosettes added in the 1430 period, and hexagonal graupel in the third. Samples are shown in Figure 8. The snow rate meter equivalency plots for these and surround-

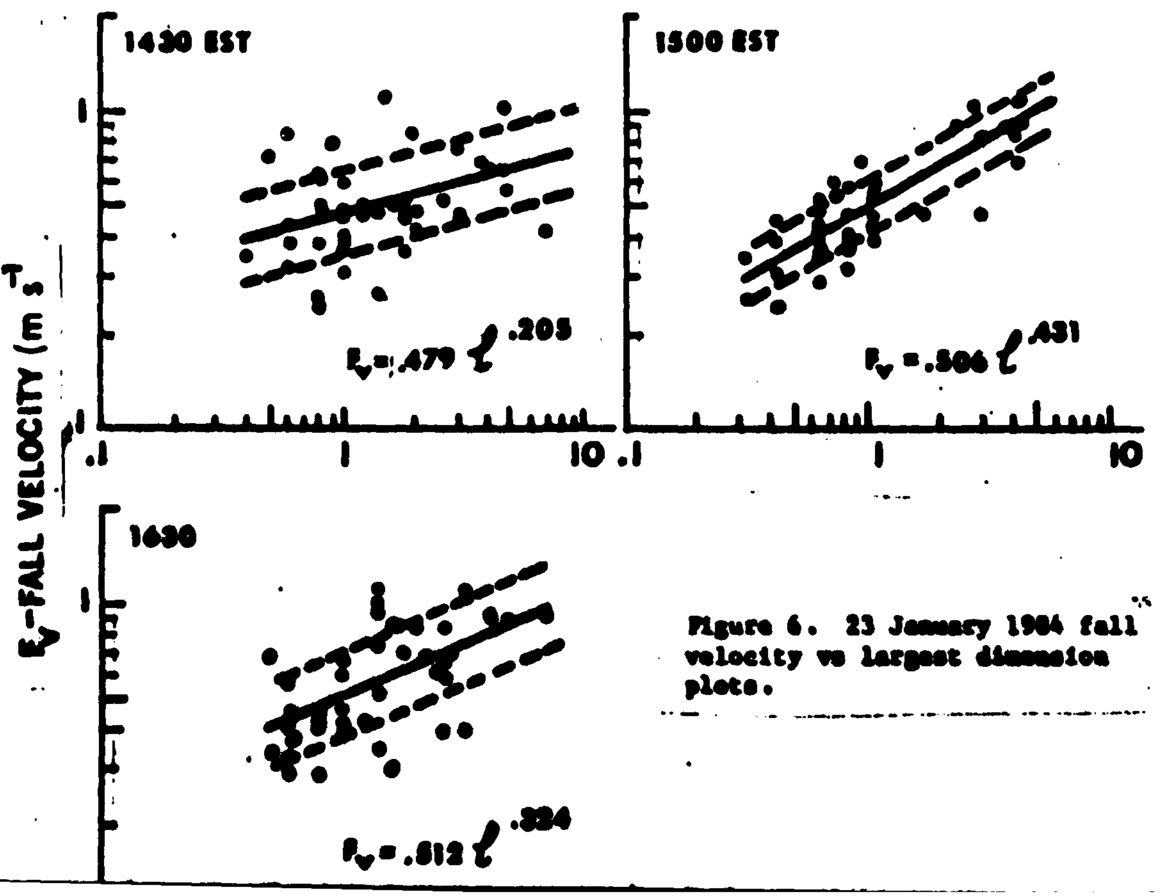

Figure 6. 23 January 1984 fall velocity vs largest dimension plots.

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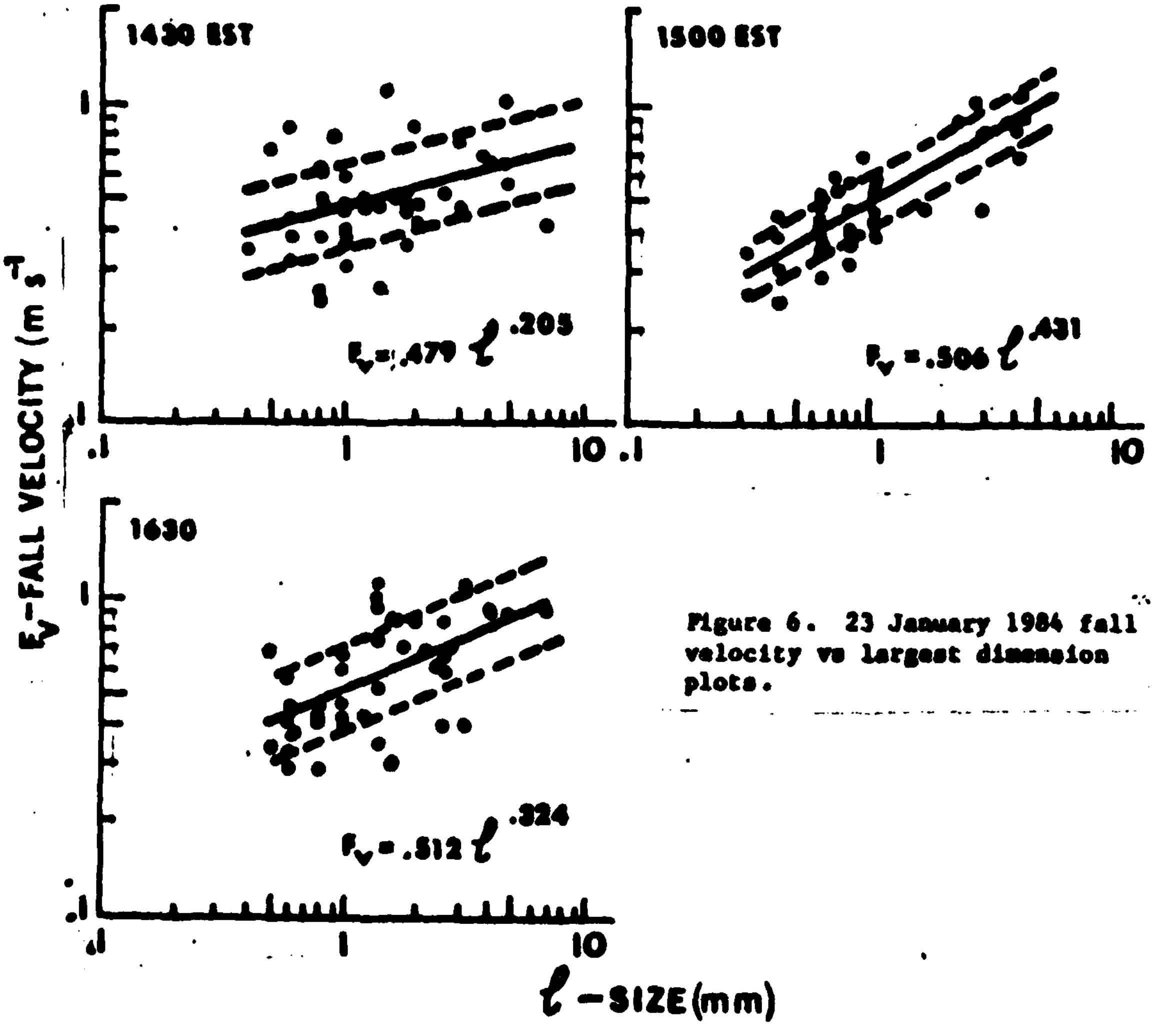


Figure 6. 23 January 1984 fall velocity vs largest dimension plots.

ing periods are seen in Figure 9. The largest snow rate recorded was 2.2 mm hr^{-1}, while the three study periods show maximum rates between 1.3 - 1.5 mm hr^{-1}.

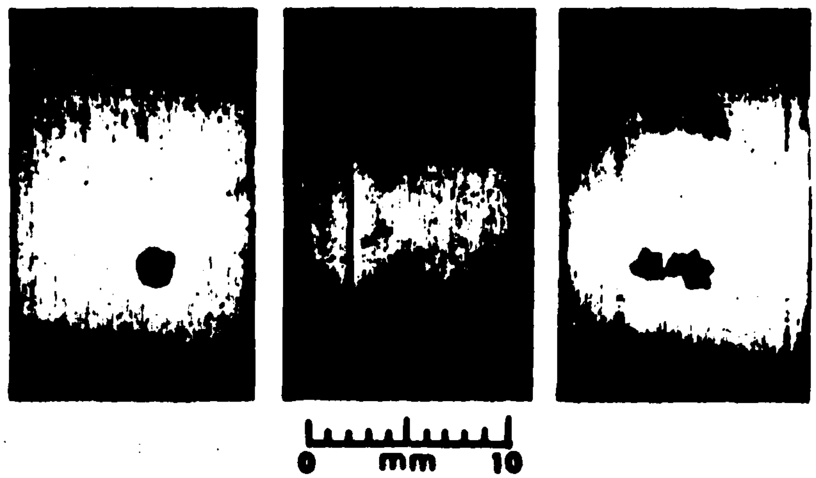


Figure 7. Fall velocity indicator particle images on 23 January 1984.

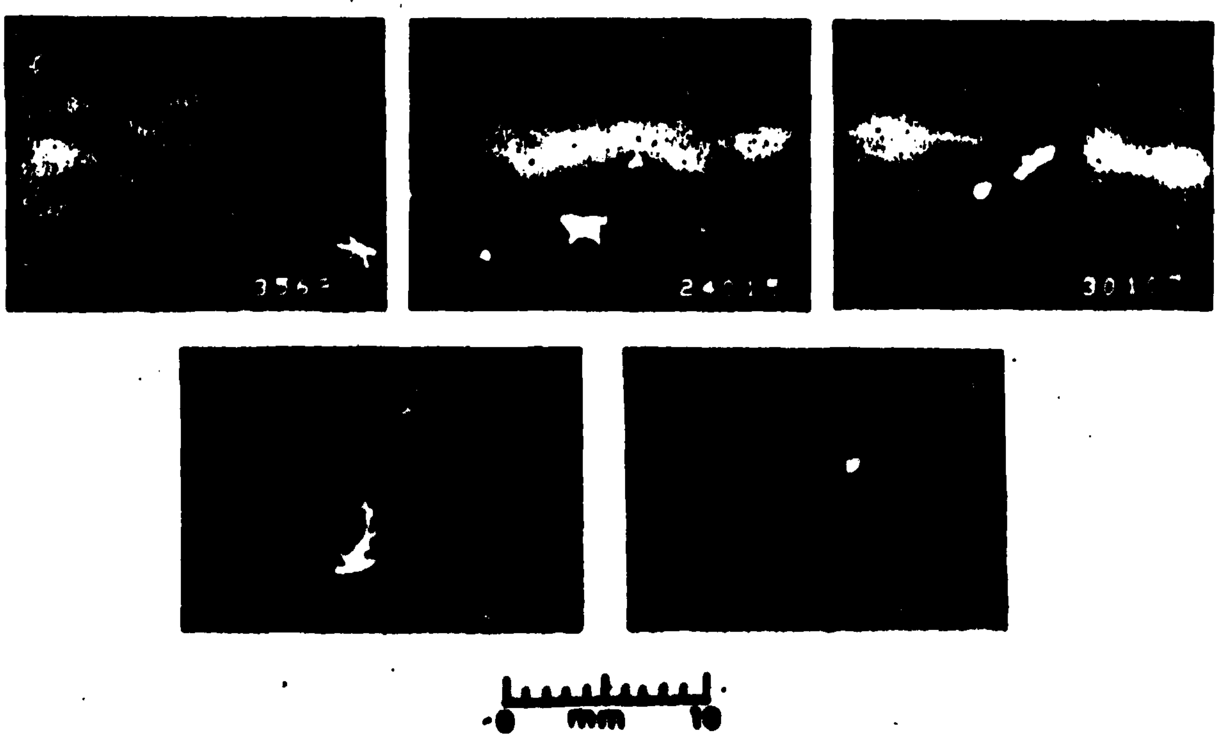
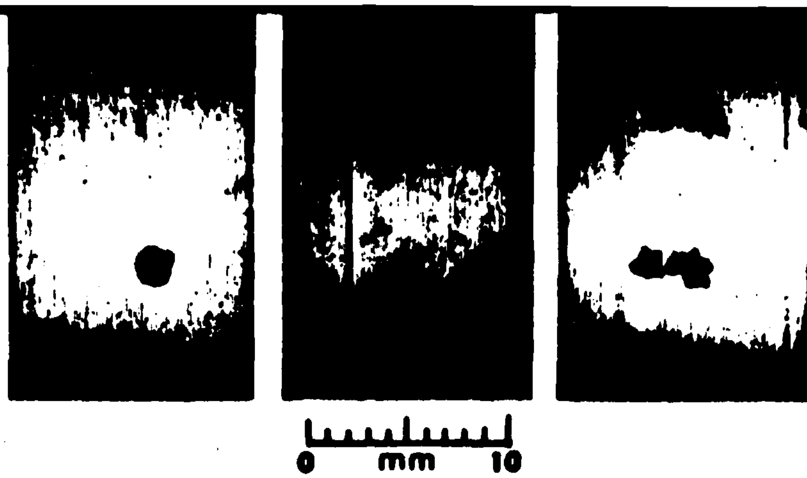


Figure 8. 23 January 1984 snow structure recorder samples.



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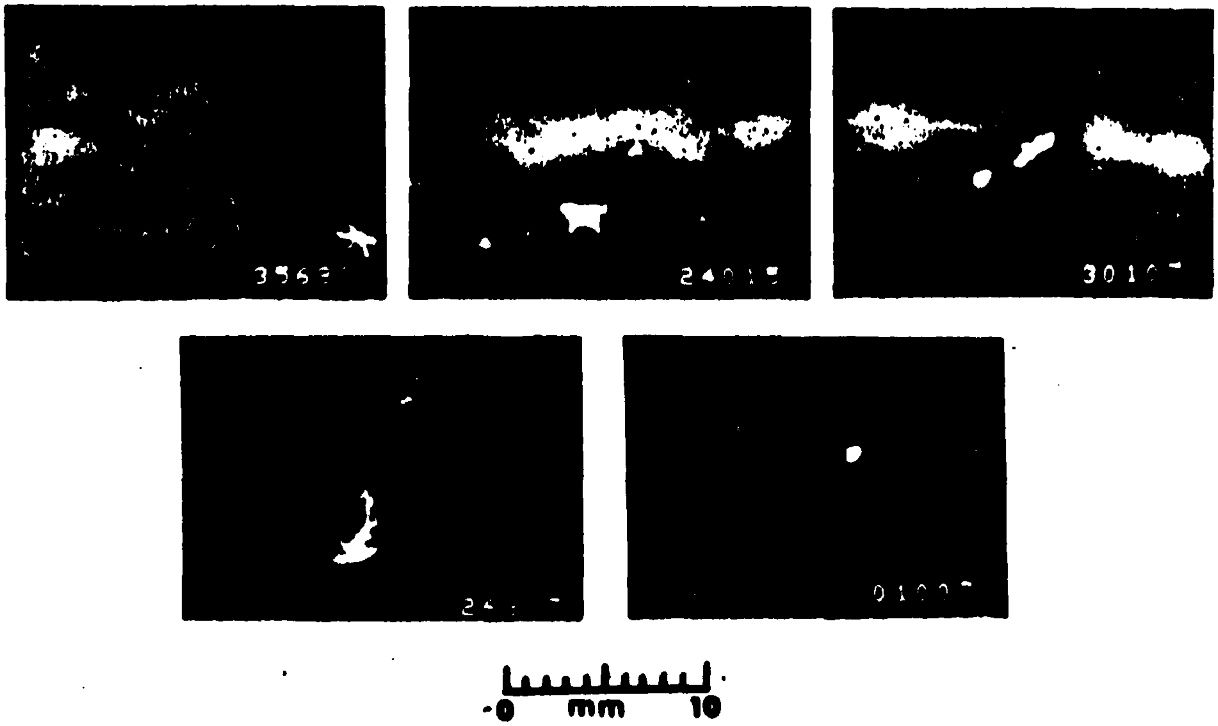

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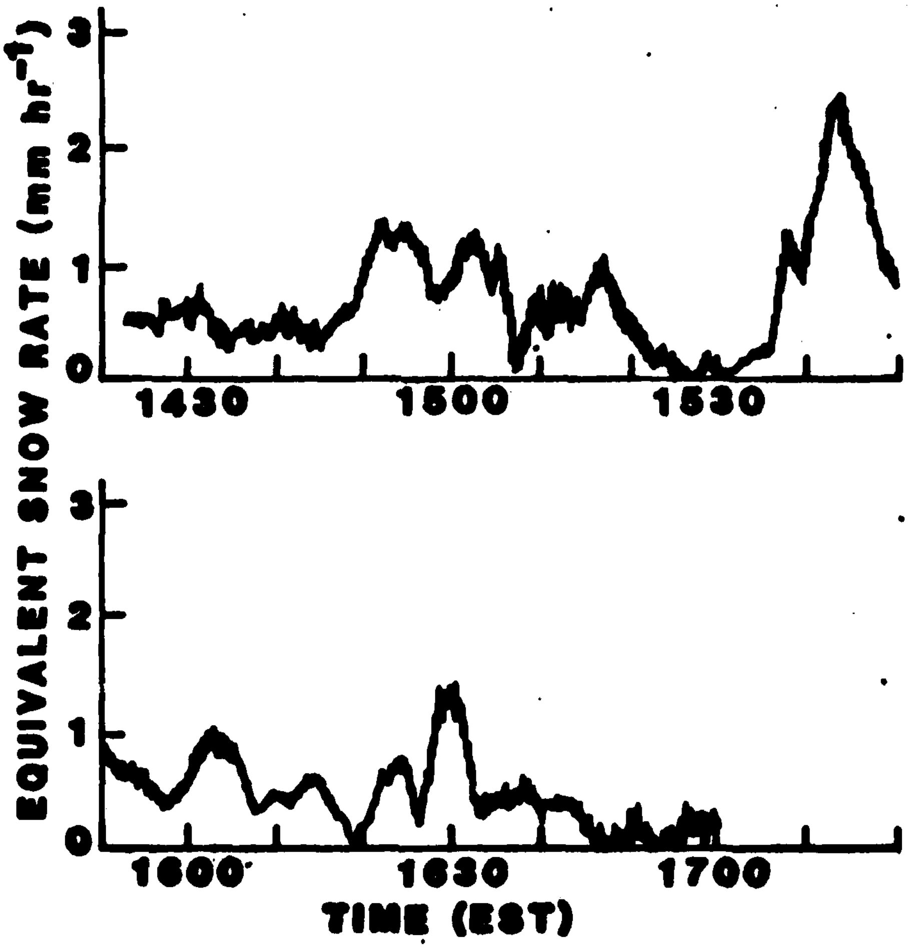


Figure 9. 23 January 1984 snow rate plots.

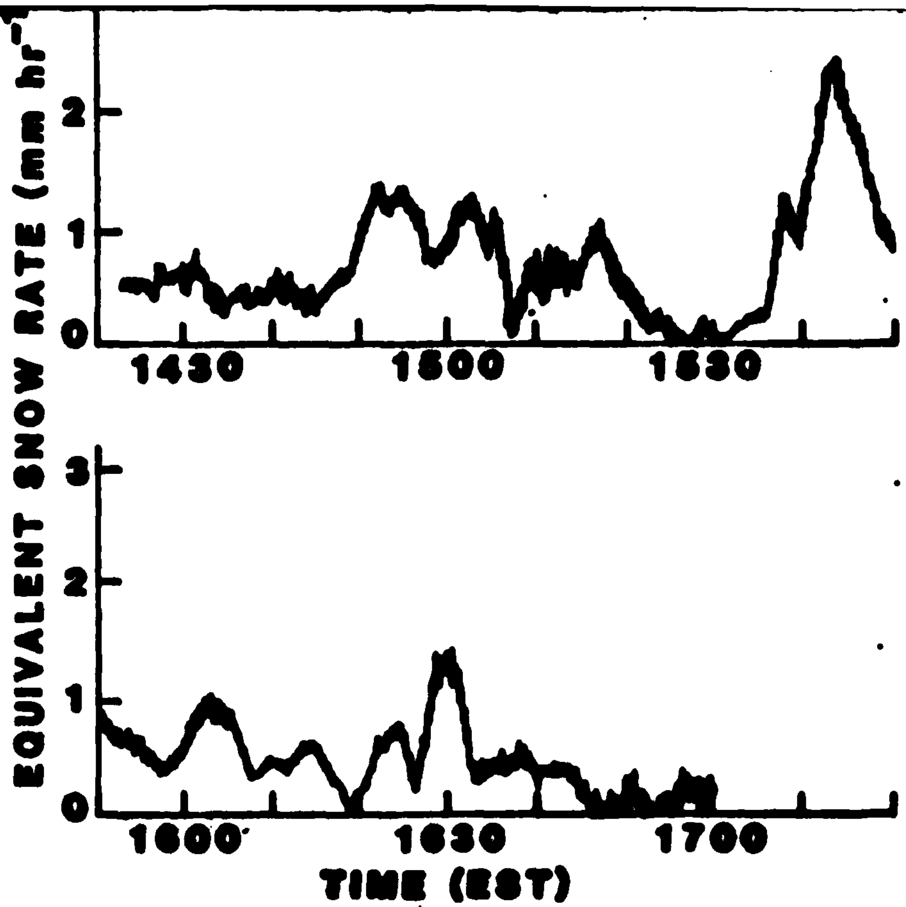
Conclusions

We have compared the fall velocity relationships from SNOW-TWO/Smoke Week IV with those of SNOW-ONE-A and B (Berthel et al, 1983). The equations derived from the 23 January 1984 data generally match those from SNOW-ONE-B. The equation coefficients conform with those obtained on 16 January 1984, although the slopes from the 16th's data are generally smaller. The most obvious difference is seen in the coefficients from SNOW-ONE-A's 31 January 1982 storm. These coefficients were approximately forty percent higher.

The data gathered thus far in the SNOW projects are the beginning of a data base. We feel that the refinements made in both instrument performance and data reduction techniques will enable us to expand this base greatly. It is hoped that by sampling a wide variety of particle sizes that we will be able to derive equations that will be applicable to broad categories of crystal types.

Recommendations

While the instrument modifications made following SNOW-ONE-B proved suc-



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Conclusions

We have compared the fall velocity relationships from SNOW-TWO/Smoke Week IV with those of SNOW-ONE-A and B (Berthel et al, 1983). The equations derived from the 23 January 1984 data generally match those from SNOW-ONE-B. The equation coefficients conform with those obtained on 16 January 1984, although the slopes from the 16th's data are generally smaller. The most obvious difference is seen in the coefficients from SNOW-ONE-A's 31 January 1982 storm. These coefficients were approximately forty percent higher. These comparisons may indicate that the particle mix on 23 January 1984 and 12 December 1982 were somewhat similar to 16 January 1984, having slow falling flakes in the large size category. The equation from 31 January 1982 could be explained by the presence of particles of higher densities; however, at this point, that is pure speculation.

The data gathered thus far in the SNOW projects are the beginning of a data base. We feel that the refinements made in both instrument performance and data reduction techniques will enable us to expand this base greatly. It is hoped that by sampling a wide variety of particle mixes that we will be able to derive equations that will be applicable to broad categories of crystal types.

Recommendations

While the instrument modifications made following SNOW-ONE-B proved successful, as demonstrated by the better definition in FVI data, we feel that further changes may be indicated. Studies are currently taking place in the laboratory on the feasibility of using polarized light to enhance our ability to see and measure the smaller particles through better definition. The sampling volume of the FVI has been increased and

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proper focal length adjustments made. This should increase greatly the number of particles available for study. The possibility of digitizing the image is being explored, as well. Although the addition of a rotary table to improve collecting efficiency did not receive an indepth test because of very scant snow fall and horizontal wind problems, it does appear to have had some success and plans are being made to mechanize the table for easier use. A snow volume recorder should be completed by the fall of 1984 and in operation for next winter. Work is being started on the development of an AFGL ASCME along the lines of those being used currently by CRREL. We hope to have this available in the near future. The data gathered in SNOW TWO/Smoke Week VI still leaves unanswered questions regarding wind effects and accuracy of small samples. Preliminary airflow studies have been conducted but further studies are necessary before full assessment can be made. It is expected that these studies will be conducted by fall 84. We have defined no fault in the SRM operating in light snow and assume the recorded data to be correct. Further studies will be performed as comparison data becomes available.

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